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The Use of Pump-Out Facilities by Recreational Boaters in Maryland

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ABSTRACT: Because of the intense interest in the water quality of the Chesapeake Bay, the State of Maryland sponsored a survey of 500 Maryland boaters to determine their use of marina facilities to discharge sewage from portable toilets or holding tanks. We report results of that survey as well as examine some of the factors that contribute to the use of pump-out facilities. Presently, with under 10% of Maryland's marinas having facilities available to pump out holding tanks or portable toilets, less than one in twenty boaters has ever used such a facility. Moreover, less than one in three boats equipped with holding tanks or portable toilets has ever used such a facility. Using a discrete choice behavioral model, we found that boaters with portable toilets were more likely to use facilities than ones with holding tanks, especially if the holding tanks were equipped with macerating devices. The price of using the pump-out facility negatively influenced pump-out use. We also found that vessels in transition were less likely to use marina facilities. Finally, the availability of a pump-out facility at a boater's marina increased the likelihood of pumping by twofold. In Maryland reduction of boat-generated pollution will likely require a policy of both extensive pump-out services and low costs for the services.

Introduction

The Federal Water Pollution Control Act (FWPCA), as amended in 1972 (Public Law 92-500), assigned the United States Environmental Protection Agency (EPA) and the United States Coast Guard (USCG) the responsibility to eliminate discharges of raw sewage from all vessels including recreational boats in navigable waters of the United States. They in turn mandated that all vessels with "heads" would need after 1980 marine sanitation devices (MSDs) installed (United States Coast Guard 1987; United States Environmental Protection Agency 1987). The purpose of the devices is to treat sewage before discharge (Types I and II MSDs) or to hold it on board until a facility (usually a marina) with a pump-out service can be reached (Type III MSD). This requirement, in conjunction with laws regulating the effluent content of overboard discharge, presumably was meant to eliminate the problems of disease, eutrophication, odor, and other aesthetic offenses associated with discharge of waste from recreational boats.

Unfortunately, the intended result may not have evolved. While the Coast Guard and Auxiliary include MSDs in their inspection practices, difficulties with monitoring overboard discharge and the increased burden of policing drug traffic by the USCG have prevented any rigorous enforcement of the law. Boats equipped only with holding tanks can illegally pump directly into the waterways. Effluent from boats with Type I and II MSDs also may not meet water quality standards. Thus, it would appear that the law prohibiting raw sewage discharge is enforced largely by moral suasion; that is, the knowledge that pumping raw sewage overboard is unlawful and harmful will cause individuals to incur costs to avoid violating the law and degrading the environment.

A reasonable question to ask is how effective is moral suasion in preventing overboard discharge of raw sewage. The fact that less than 10% of Maryland marinas have facilities capable of pumping out holding tanks and that these facilities are infrequently used suggests not many boaters are meeting the spirit of the law (Gibson and Arnold 1988). However, more detailed information on the use of pump-out facilities or the alternative Types I and II MSDs by boaters is required to answer the question properly.

The purpose of this paper is to begin to understand the factors influential in recreational boaters' use of pump-out facilities. The next section provides details concerning the technology of holding tanks and pump-out facilities. A conceptual model

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of the pump-out facility use serves as a basis for examining the behavior of a sample drawn from Maryland recreational boaters. The sample of Maryland boat owners and the statistical analysis is then described. Policy implications and conclusions are drawn in the final section. Whereas the paper does not address the violation of effluent standards by vessels with Type I and II MSDs, it is a preliminary attempt to describe the behavior of recreational boaters using MSDs.

The Technology of MSDs

The FWPCA amendments passed in 1972 (Public Law 92-500) required the EPA to prevent the discharge of untreated or inadequately treated sewage into the nation's waters and to make the waters safe for fish, shellfish, wildlife, and recreation. FWPCA further stipulated that the USCG was to enforce the sewage discharge standards developed by the EPA. The Administrator of EPA designated that vessels were to have MSDs on board and their effluent was to meet certain standards.

There are three types of MSDs, each with different standards.

> The macerator (MSD Type I): A device which grinds the waste. The effluent should not have a fecal coliform count greater than 1,000 mpn per 100 ml or visible floating solids.
> The macerator/chlorinator (MSD Type II): A device which grinds the waste and disinfects it. The effluent is similar to that of secondary treatment plants and should not have a fecal coliform count greater than 200 mpn per 100 ml or suspended solids greater than 150 mg l^{-1}.
> The holding tank (MSD Type III): A tank installed in the vessel which contains the sewage until such time that it can be pumped out.

In addition to MSDs, boat owners can also utilize portable self-contained toilets or "port-a-potty" type devices. These do not have standards, as such vessels do not technically have an installed head, and there is no clearly defined practice for the proper discharge of their contents.

Boat owners who installed any MSD before 1977 would likely be considered in compliance with the federal law for the life of the installed device. Beginning in 1977 greater restrictions were placed on MSDs. They applied to new vessels as of January 30, 1977 and to existing vessels as of January 30, 1980. The new restrictions required essentially that any boat with installed toilets must meet or exceed the Type II discharge standards or comply with the retention conditions of a Type III holding tank (United States Environmental Protection Agency 1987). Other provisions of Federal law require that boats on freshwater lakes, reservoirs, or impoundments must use holding tanks for their sewage. Any flow-through treatment devices must be secured to prevent discharge into these waters.

A number of problems have become apparent in meeting the spirit of minimal or no-discharge by using MSD regulations. First, they inconvenience recreational boaters because MSDs are space consuming on vessels where space is scarce, and they are difficult to retrofit. Type II requires a large power source, usually battery supplied, that small boats and sailboats do not have, and they are also easily clogged, hard to fix, and expensive to replace. Because of the difficulties with the Type II device, EPA and the USCG authorized a waiver to permit continued use of Type I MSDs on boats less than 65 feet long (Department of Transportation 1978). Holding tanks have other problems including lack of pump-out services and potentially offensive odors. They are legally allowed to have a "y" valve to provide overboard discharge of untreated sewage when the vessels are at least three miles from shore (Arnold 1987).

An important consideration in whether the boat owners comply with the law may be whether their home port marinas have pump-out facilities. Not many marinas have pump-out facilities for holding tanks in Maryland; 29 facilities existed in 1985, even though about 400 marinas were currently in operation (Gibson and Arnold 1988). Reasons so few marinas in Maryland have pump-out facilities include the nuisance of keeping them operational and the lack of profit in operating them. The occasional spill and routine odor problem make the facilities mildly troublesome. Crowding is not a problem at existing facilities, and boaters are not offering great sums of money to have someone pump out their vessels' holding tanks. The inability to enforce the discharge standards and prohibitions may contribute to this circumstance. Indeed, it is surprising that boat owners demand the facilities at all.

A Model of Demand for Pump-Out Use

The recreational boater's decision to allocate time and money to pump out holding tanks must be considered in a slightly unconventional manner. Since there is a strong potential for illegal behavior on the part of boat owners, we look to the literature on illegal activities. Economic arguments for illegal behavior consider the factors which influence the number of illegal offenses (Stigler 1970). Among Stigler's determinants of illegal behavior are included potential payoff, the structure of penalties, and the probability of being convicted.

In our particular situation, Stigler's factors have to be explained and expanded. The only payoff to

TABLE 1. Average characteristics of boaters interviewed at marinas with and without pump-out facilities.

Characteristics	Marinas with Pump-out Facilities[a]	Marinas without Pump-out Facilities[b]
Days boat used per year	80.5	71.9
Days boat left slip per year	41.2	44.6
Nights people sleep over per year	63.4	56.1
Average number of people sleeping over	2.5	2.3
Boat length (feet)	33.0	32.1
Size holding tank (gallons)	22.7	28.0
MSD Type I or II aboard (%)	31.7	30.4
Holding tank aboard (%)	47.9	47.6
Port-a-Potty aboard (%)	16.7	19.6
Use of pump-out facility (%)	24.8	12.5

[a] Averages based on 227 interviews at 29 marinas with pump-out facilities.

[b] Averages based on 273 interviews at 29 marinas, chosen to "match" marinas with pump-out facilities.

the recreational boater for illegal overboard discharge is an avoidance of certain costs. In most instances, an economically rational individual would choose to discharge raw sewage overboard, avoiding the odor problem associated with sewage storage and the cost of pumping the sewage from the holding tank. The law will only influence those who are informed of its content and who do not know it is not enforced, or those who have a sense of social conscience. We hypothesize that the likelihood of illegal activity rises as the payoff from it rises.

The boater's decision is conjectured to be composed of a sequential choice: to use the pump-out facilities, and then how frequently to pump, conditional on the choice to pump. In essence, we think of the individual as having a set of circumstances that causes him to choose whether or not to use pump-out facilities, and once having made that decision, as having another set of factors leading him to use pump-out facilities more or less frequently.

Unfortunately, the data which are available to analyze the two decisions are not consistent with a methodology in which they may be integrated. The frequency-of-use data consist only of whether individuals pump out between one and four times per year or more than four times. Thus, a model (Cragg 1970) with a probit/logit analysis of the choice to pump out and a sample selection model for the number of pump-outs conditional on pumping is ruled out. Moreover, there is no choice-specific information about the frequency-of-use decision, so a nested logit approach (McFadden 1973; Kohn et al. 1976) is also inappropriate.

The data reduce our analysis to the treatment of the problem as two independent events. The first is the choice of whether or not to use pump-out facilities. We assume the i[th] individual decides to pump based on some set of factors, z_i. The utility associated with pumping is assumed to be related to the factors according to $v_i^* = \beta_i z_i + \epsilon_i$ where ϵ_i is an error term. We observe the pump-out use according to

$$\begin{aligned} v &= 1 \quad \text{if } v^* > 0 \\ v &= 0 \quad \text{otherwise} \end{aligned}$$

and the probability of any pumping is given by

$$\begin{aligned} \text{prob}(v = 1) &= \text{prob}(\epsilon_i > -\beta_i z_i) \\ &= 1 - F(-\beta_i z_i) \end{aligned}$$

where $F(\cdot)$ is the cumulative distribution of our assumed logistically distributed error, ϵ_i. With this assumption, we can perform a logit analysis.

The second choice of how frequently one pumps, given that pumping occurs, is also examined using a logit analysis. The model is $y^* = \gamma_i x_i + \eta_i$ where η_i is assumed logistically distributed. We observed values for our qualitative variable, y, according to

$$\begin{aligned} y &= 1 \quad \text{if } y^* > 4 \text{ (frequent use)} \\ y &= 0 \quad \text{otherwise.} \end{aligned}$$

The Sample of Maryland Marina Users

Maryland's Department of Health and Mental Hygiene decided in 1986 to study pump-out use through a survey of marina owners and users. The survey was conducted from Memorial Day weekend through Labor Day weekend, 1986. Twenty-nine marinas providing pump-out facilities during the survey period were visited, and another 29 "matched" marinas without pump-out facilities were visited.

In addition to the marina operators, boaters in each of the marinas were interviewed. A total of 500 interviews were obtained; 273 interviews were taken from boat owners at marinas without pump-out facilities, and 227 were from boat owners at marinas with pump-out facilities. Means of responses to interview questions are presented in Table 1. The means are quite similar between groups. Matched marinas were paired, and a Mann-Whitney U-test was employed to test significant differences for the first six variables. The average number of people who occasionally slept on board was the only variable significantly different, with more people sleeping on board in marinas with pump-out facilities.

The use of the pump-out facilities by boat owners was surprisingly low. Only one-third of boaters with holding tanks installed in their boats had ever used a pump-out facility. Of all boat owners, less than one in five had ever been on a boat which had its holding tank pumped out.

The sample interviews also provide a number of variables which may be important in determining pump-out use. These are defined below with acronyms and mean values for the sample.

HT	Holding tank on board (HT = 1 if yes; 0 otherwise), 0.43
CTNK	If HT > 0, holding tank capacity, 26.9 gallons
MAC	Macerator/macerator-chlorinator on board (MAC = 1 if yes; 0 otherwise), 0.27
FEE	Fee charged for last pump out, $12.08
AV	Availability of pump-out facilities at home marina (AV = 1 if yes; 0 otherwise), 0.46
PAP	Port-a-potty on board (PAP = 1 if yes, 0 otherwise), 0.20
TRNS	Interviewed boat in transit (TRNS = 1 if yes, 0 otherwise), 0.18
USE	Index of use formed by multiplying people on board with the sum of the numbers of times per year the boat was used and the number of times people slept on it, 146.7

The choice of whether or not to pump out a holding tank or appropriately empty a port-a-potty is hypothesized to be related to these variables or combinations thereof. The exact model is

$$\begin{aligned}\text{prob}(v = 1) = 1 - F(&-\beta_1 HT - \beta_2 MAC \\ &- \beta_3 TRNS - \beta_4 PAP \\ &- \beta_5 PAP \cdot COST \\ &- \beta_6 HT \cdot COST \\ &- \beta_7 AV \cdot USE \cdot PAP \\ &- \beta_8 AV \cdot USE \cdot HT)\end{aligned}$$

where the F is previously defined as the cumulative distribution of the logistic function.

Our expectations of the signs of the β_i can be summarized as follows:

$\beta_1 > 0$:	the existence of a holding tank, by itself, should increase the probability a boater will use a pump-out facility;
$\beta_2 < 0$:	the existence of a macerator or macerator-chlorinator should reduce the need to pump out;
$\beta_3 < 0$:	boats in transit are likely to be at least three miles from shore more often and hence more likely to discharge "at sea";
$\beta_4 > 0$:	port-a-potties require dumping, and marinas with pump-out facilities offer an alternative;
$\beta_5, \beta_7 < 0$:	the higher the potential money (time) expenditures on port-a-potty pumping, the more likely boaters will find alternatives;
$\beta_6, \beta_8 < 0$:	the higher the potential money (time) expenditures on holding-tank pumping, the more likely boaters will find alternatives.

TABLE 2. Logit analysis estimation and prediction results for pump-out facilities use.

Factor	Coefficient	Estimate (*t*-statistic)
Holding tank (HT)	β_1	NS
Macerator device (MAC)	β_2	−1.754 (−5.50)
Transition vessel (TRNS)	β_3	−1.00 (−2.67)
Port-a-Potty (PAP)	β_4	2.14 (2.60)
Potential cost of Port-a-Potty pumping (PAP FEE USE)	β_5	−.005 (−3.78)
Potential cost of holding tank pumping (HT FEE USE)	β_6	−.0006 (−4.59)
Potential ease of Port-a-Potty pumping (PAP AV USE)	β_7	.025 (2.92)
Potential ease of holding tank pumping (HT AV USE)	β_8	.008 (2.73)

Behavior	Prediction Results		
	Predicted	Actual	Percent of Individuals Predicted Correctly
Use of pump-out facility	66	82	65% (43/66)
Not use pump-out facility	381	365	94% (342/365)

The choice of whether to pump many times (y = 1) or a few times (y = 0) is considered according to

$$\begin{aligned}P(y = 1) = 1 - F(&\gamma_1 \cdot CTNK - \gamma_2 \cdot PAP \\ &- \gamma_3 \cdot FEE - \gamma_4 AV).\end{aligned}$$

Our belief is that $\gamma_1 < 0$, $\gamma_2 < 0$, $\gamma_3 < 0$, and $\gamma_4 < 0$. A greater holding tank capacity should lead to less pumping. Likewise, port-a-potty availability may allow greater flexibility in disposing of wastes. High fees should discourage use, whereas availability should encourage use.

Results

The results of the logit estimation for use are presented in Table 2. They were obtained using LIMDEP (Greene 1986) on an IBM 4381 computer. Choice-based sample weights and weights for representativeness of boaters were used in the estimation. The significance of coefficients suggests our selection of factors was not unreasonable. Moreover, our ability to predict pump-out use was considerable. Of the 64 persons who pumped, our model correctly predicted two-thirds of them would pump. Moreover, 94% of those who did not pump were predicted correctly. Remarkably, the only factor which was not statistically significant in determining the probability of using a pump-out facility was the holding tank variable, by itself. It did not explain significant variation in whether boaters use pump-out facilities unless it interacted with other factors. As a result, it was dropped from the

TABLE 3. Logit analysis estimation and prediction results for frequency of pump-out use.

Factor	Coefficient	Estimate (t-statistic)
Capacity of holding tank	γ_1	−.0088 (−1.18)
Port-a-Potty	γ_2	−.84 (−1.16)
Fee	γ_3	−.77 (−1.58)
Availability	γ_4	1.50 (2.34)

	Prediction Results		
Behavior	Predicted	Actual	Percent of Individuals Predicted Correctly
Infrequent pump-out use	32	32	56% (18/32)
Frequent pump-out use	50	50	74% (37/50)

reported results. The results show that the combination of having a holding tank and the amount of time and money to pump it influence the probability of pumping.

To illustrate the importance of the availability of pump-out facilities and the price charged for pumping, a series of conditional probabilities was computed for the model shown in Table 2. As a basis, the probability of pumping out for the representative boat owner was computed using the average values for the factors in the model. Approximately one in 10 boat owners would use pump-out facilities. We then computed probabilities of pumping conditional on having pump-out facilities available at all marinas (AV = 1). The predicted conditional probability for this case indicated that one in five boat owners would use pump-out facilities. Finally, we kept availability at all marinas and lowered the price from the average of $12.08 per pump out to $5 per pump out. The predicted conditional probability rose to over 0.5; one in every two individuals would use pump-out facilities.

The effect on the conditional probability of changes in the macerator-chlorinator variable and transient boater variable was not as profound. Eliminating the use of macerator-chlorinator (MAC = 0) raised the conditional probability of pumping out, but only so that about one in eight owners would pump out. The effect of reducing transient boaters in the model was even less.

The results of the logit analysis for frequency of pump-out use are shown in Table 3. The statistical significance of the coefficients is not as powerful as the previous results. Coefficients on capacity, fees, and the port-a-potty variable are only marginally significant. However, the availability coefficient was strongly significant, and the ability of the model to predict was reasonable.

We were able to predict the effect of changes in the availability of pump-out facilities and fees on the conditional probability of request use. The conditional probability of frequent pumping (four times annually), given that the boat owner pumps, was estimated to be about one in three. If the availability of these facilities rose from the average of 16% to 100%, the conditional probability of frequent pumping would rise to one in every two boat owners. Dropping the price to $5 per pump out had little effect on the conditional probability of frequent use.

Consequently, management efforts in Maryland to reduce boat-generated pollution will require considerably expanded marina pump-out services and an effort to keep the fees reasonably low. This could be achieved by mandating pump-out services as a condition of marina operation, limiting construction grants to such marinas, and/or providing tax incentives to such construction and operation. Price ceilings on the use of these marina services might also be needed to assure continued boat-owner use.

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